Plant Wide Control of Chemical Processes
Prof. Nitin Kaistha
Department of Chemical Engineering
Indian Institute of Technology, Kanpur

Lecture - 31
Role of Equipment Capacity Constraints

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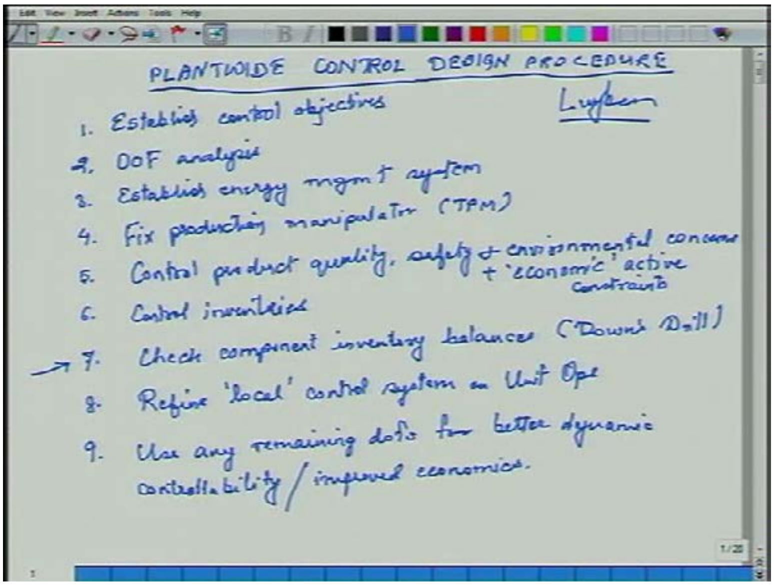

So, welcome to the next class, today one day after 16th August an eventful day, right. We were looking at a plant wide control design procedure, which is attributed to Luyben. They were the first ones to sort of systematize systematize, what needs to be done, and the basic idea is do, the most important thing. First, what is most important is stabilization particularly, if you got exothermic reactions, you need to establish an energy management system. First, you need to make sure that, whatever heat is being released by the reaction is effectively removed right. So, that there is no possibility of a thermal run away, that is all; that this means and what I was trying to tell you, last time was that reaction systems and heat corresponding heat removal systems are designed; and that design itself tells, you the best way of removing heat in terms of control right.

That is what, I was trying to tell you last time, then you fix production and before controlling inventories, you control everything else that is more important. So, product quality is going to be more important, what else any safety considerations. For example; flammability limit process of operation, should never wander into the flammable region right, that is important and any environmental concerns. So, these variables will have to be tightly controlled in order to control them; tightly you need handles; that are close by right, if the handle goes far away, then there is a large lag; and if there is a large lag, the control cannot be as straight right. So, these things need to be done, when you have the maximum availability of valves.

So, you taken some valves away for reactor stabilization, you have taken one valve away for throughput manipulation, then your next in terms of priority concerns or product quality safety, and environmental. You form loops, that will give you tight control right; that means, you have to use close by handles, right. After that, you will still be left with sufficient number of valves to regulate inventories; that essentially fixes your control system never the less, the plant wide control system never the less, because some mistakes can happen in terms of putting in place a control system; that does not respect over all component inventory balance, for at least one component or sometimes may be even total material balance.

It is important to check, that whatever control system you have put in place; it respects material balance, everything that is coming into the process; either gets reacted away or finds a way out right double check that. So, this is step number 7 is essentially double checking this, that the mistake is not been made, because if a mistake has been made, that control system is doomed guaranteed, something will build up or something will deplete, and then you will have to take a shutdown guaranteed. So, it is important to stress point number 7, usually after you have done all of the above, you have put in you have stabilize, the heat you stabilize the exothermic reactor you have chosen.

A throughput manipulator, you have put in place loops for product quality control, safety concerns, environmental concerns, you have put in place loops for controlling levels and pressures and component inventories. If necessary you will still have degrees of freedom, that are left; those degrees of freedom can be used to tighten up the control on a local unit operation. For example: in a distillation column, you may say that, I am Going to keep the reflux rate fixed, but to improve the energy efficiency of that column.

You may say that, instead of controlling 1 tray temperature, I will control 2 tray temperatures, and now I am going to move my reflux rate in to maintain. For example: a rectifying tray temperature, what that does is it actually improves the energy efficiency of your process? You consume less steam for the same production. Similarly, you can think of whatever valves are left, whatever degrees of freedoms are left. They can be used to improve the control of local unit.

In a, for example: In a furnace in order to ensure that, the combustion is near complete, you will always be monitoring the stag gas composition, and then adjusting the fuel to air ratio, to ensure combustion is near complete right; that is true basically have efficient furnace operation, whatever fuel you are putting, in which is precious must get fully combusted right.

So, there always be degrees of freedom, that can be adjusted for more efficient unit operation control do that; and there are books, that are available, that will help you do that. I mean, that is that is pretty, reasonably, well established, even after doing that, you will you will usually still have a few degrees of freedom; that are left; those can be used to either improved for either better dynamic controllability, smoother operation, or for improving economics. For example: Yields process, yield separation of side reaction etcetera. So, this is the 9 step procedure. I hope, the hierarchy and why what is being done first? And what is being done next is organized the way, it has been organized.

Inventory control is usually tight inventory control is usually not desired, it is not important to have tight inventory control. In fact, if you have put in place a reflux drum or let us say a surge drum and you are doing perfect level control; what does that mean? If flow in changes, flow out changes immediately as like in compressible flow. Why the hell did you put in place that drum to begin with? You put in place, the drum to dampen out flow variability.

But, then your level control is extremely tight, flow variability is not getting dampened out right. Flow increases, level control is perfect, flow out also increases simultaneously, where is the dampening of flow variability? Right. Why the hell did you put in place that surge drum to begin with? You might as well have put a straight pipe yeah. So, the whole point is that, the such inventories are actually shock absorbers like in a car.

You Want that shock absorber to moves, you want it to fluctuate, within limits of course, so that the shock absorber, you know does not damage the shock absorber itself. So, it should not happen, that the tank level goes down below 20 percent; and alarm start going off, or that a tank level should go beyond 80 percent; and again alarm start going off. As long as, the variability is allowed to be in that band, you are absorbing shocks yeah.

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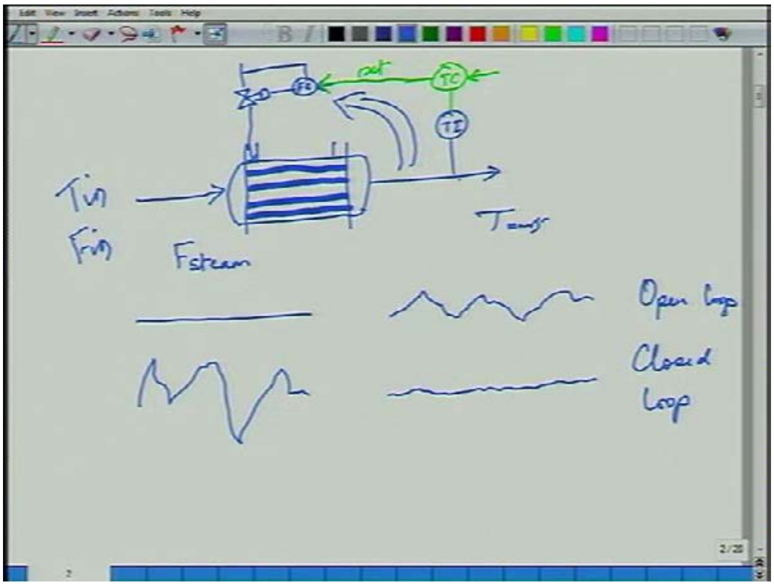

And just to give you a perspective on this, I think it is important to this, is very simple example: But, it sort of captures, what is being said? Let us say, I have got a heat exchanger, you know. Let us say, there is a process stream; that goes through the tubes, and let us say, you are heating it using steam. So, this steam going in, you got a temperature indicator here; and what this temperature indicator is doing is, showing you what the temperature of the process streams.

Let us say, it is important that, this temperature should be held flat, should be held constant, may be this is something that is going into a reactor, and it is important to not let that temperature fluctuate. If that is the case, and let us say you are running this guy like this, is a flow controller of stream and this set point is set by the operator. Now, let us say the flow through the heat exchanger, maybe I should also show some, so these are tubes, so this is the heat exchanger process steam is flowing through the tubes, steam is on the shell side heating it up.

Now, because the temperature of whatever is the process stream; that is going in T in, because T in varies, because F in varies and also may be because, the pressure of the steam varies. What will you see on the temperature side, on the on the exit side, on the on the process stream outside? What will happen to the temperature? It is going to fluctuate right, because of the all these reasons, you are holding the steam constant, because the flow rate through the heat exchanger is changing, because the temperature of the field stream is changing, and steam is held constant.

You are Going to see that, the temperature is varying now for whatever reason, you decide that look this variability in the temperature is not acceptable, because for example, its feeding a reactor or may be a distillation column or whatever that being the case, you see well, what I am Going to do? Now, is put in place a control a cascade a control system; what that does is takes the temperature reading compares it with the set point, and then adjusts the steam flow. Let us say, this is what, you are doing. Now what you, so in the previous case, when the green, what is in green was not, there steam flow was fixed.

This is steam flow F steam and this is T out. Under open loop operation, what you have is the steam flow rate is fixed and process temperature is changing. If you close the loop, you should put in place that green loop, now what is happening? And if it is tuned well, now temperature will be close to the set point, what you will have is may the temperature is; it will show some variability, but not too much.

And, what is happening to the steam? To hold the temperature constant, the steam is actually going all over the place, yes or no? I mean again it is very simple mind it. What has the feedback control action done; it has essentially transformed process variability from, exactly the feedback action has transformed variability from here to here; that is what feedback action is doing right. So, a control system is nothing, but an agent for transforming process variability.

Now, you have to decide, where do I want the variability to go in a plant wide control context. If I am controlling level here, by adjusting down stream flow; and let us say downstream, there is a distillation column in order to hold the reactor level constant, I am disturbing I am disturbing the separation section, the distillation column, right. I could for example, hold the flow to the distillation column constant, and control the level this way. yes or no? And, now the variability is being transformed away from the distillation column.

So, now, the whole idea behind plant wide control system design is, where is variability acceptable? And where is variability not acceptable? Obvious place, where variability is always acceptable is levels, except may be for a reactor, may be you want to operate the reactor at maximum level, because that maximizes conversion; but any surge drum level variability is acceptable. If you want to systematize this, further any constraints that are becoming active. For example: you want to run the this column at flooding, because that maximizes the recycle rate and the maximizing the recycle rate, creates maximum excess inside the reactor, and that suppresses the side reaction.

So, you got a very good reason to maximize the boil up; if you are not able to maximize the boil up, that reduces your yield, and that that is a what should I say, an economic penalty for you right. In that case, I want really tight control of the boil up too right. So, I do not want variability going towards the boil up, or towards that column, which I want to operate close to flooding, I want variability to go away from there. Do you see what I am saying? So, the whole idea is, which way should I transform the variability, you see the moment, I put in that loop in there, the moment I put in that loop in there, I am essentially saying transform variability from here to here, that is a structural decision the moment you put in a loop, you have essentially decided.

I want to take variability from here, and I want to transform it there; that came, because you structured a loop, when you are designing an overall plant wide control system; those structural decisions are in your hand right; and those structural decisions now have to be taken, so that variability is transformed away from all, for example: active constraints. Do you receive? what I am saying? That is the basic idea, and if you if you consider this prospective, you will find that loop; this actually makes sense, energy management system, if the if something Going to go unstable, you want to do it the best possible way, use the closest possible handle.

Product quality will always be an active constraint variable. Safety concern will all you want to operate close to flammability limit, but not in the flammability region right, tight control, how close can you operate that will be determined by how tight you can control it? Same thing with environmental, you know 0 discharge or you know minimum discharge right, you have to control these things tightly.

So, put in place loops; that help you do that, when you put in place the loops variability; in these variables gets transformed to whatever you have manipulating, yes or no? Control inventories comes later, and you do not want to control them too tightly, because if you try try to control them too tightly, just like I gave you the example of a simple tank; you put in place a tank to dampen out flow variability, and if you control level tightly, you essentially get no damping right.

So, this whole idea of what are my active constraints, how do I structure my control system my plant wide control system, so that the variability is getting transformed away from things; that need to be active does that make sense or no once, we have converged on this. I think, we can now proceed a little further, let me just take an example and I would like to refine this a little further.

The basic idea here is control, what is economically? What is important? First when you got maximum number of degrees of freedom in your hands, the whole key is deciding what is important? And what is not? Right. So, these guys have decided quality is Going to be important, safety is Going to be important, non metal concerns are Going to be important, control them tightly first. Then we will control inventories right, now sometimes, not sometimes all the time, when you do an economic optimization, you will find that multiple constraints are active, I just gave you an example reactor temperature max, what is it reactor level max right, column leads in flooding condition column back in flooding condition etcetera right. These do not come in product quality or safety, these are coming from economic reasons.

So, I can alter this procedure by saying plus economic active constraints. yes or no? You see because, something is an something some constraint must be active, because it gives you economic optimality, because it maximizes your operating revenue or it maximizes yield or it minimizes your energy consumption, you want to control that too tightly yeah.

So, I am just going to alter, the philosophy is the same, I am just going to say that, if I can optimize my flow sheet subject to process constraints; and that optimizer is telling me that in addition to product quality, safety in environmental concerns, this column should be flooded; that column should be flooded this level should be max, that level you know. That temperature should be max, well those things too need to be controlled tightly. yes or no? Alright well, if those things need to be controlled tightly, well I might as well do it early rather than, you know before the inventory control system has been put in place, because tight control of inventories is well.

Tight control is not desirable as long as it is in a band, it is right. So, I am going to do, so this is a slight modification philosophy is the same. Now, let us talk about examples, same examples; that we are familiar with what was the example? That we have most familiar with A plus B goes to C, C plus B goes to D, and you know C is your product, D is your by product A B recycle.

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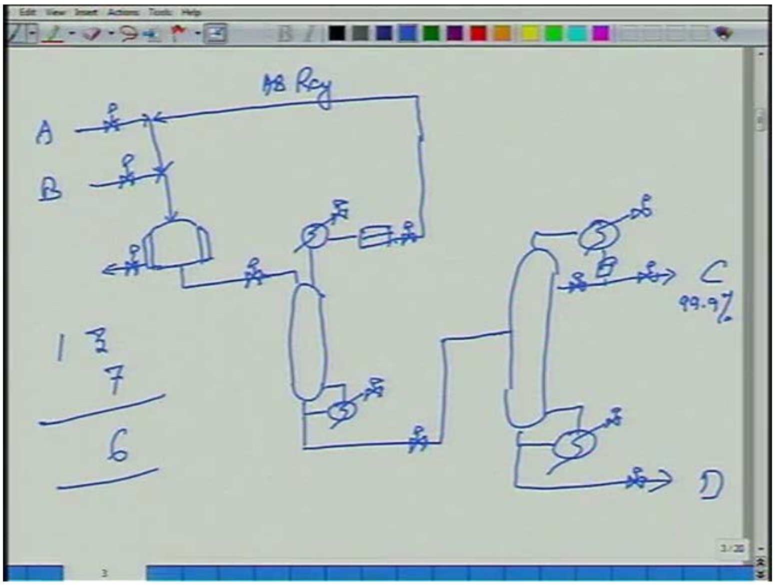

So, let us do that this is your C S T R exothermic cooled, A comes in may be B comes in, you put this into a well, I will put it in to a stripper that is done. So, that you know all degrees of freedom get exhausted; this is the stripper. The vapor is condensed condensate is collected in a drum, and we are operating essentially at 0 reflux, whatever is the condensate; it is sent to the may be recycle, bottom is essentially C and D this is send to A product column, where you take out light C of the top as the main product, by product D is taken down the bottom, and this is essentially A B recycle, this is a maybe this is B and if I start putting in valves, we got a valve here, what is the degrees of freedom steady state?

Operating degrees of freedom of this process, step number 1 control objectives, of course well, I will tell you the control objectives too, step 1 control objectives product quality, what else how about by product quality the bottom stream; let us say product quality has to be 99.9 percent, mole percent pure. Let us just say, this is what I sell in the market, what how many degrees of freedom? First of all, count them 2 for the fresh fields, 2 for the C S T R, 1 for the stripper, and 2 for the column, how many? 7 steady state operating degrees of freedom is how much 7, how many valves better question? How many independent control valves just count whatever I have drawn?

Steady state degrees of freedom is 7. Number of valves is 13, you subtract the two 6 extra valves right; these 6 extra valves are for what, inventory control, right. Now, if my steady state optimizer says that, look this is a point; that needs to be understood. I have got 7 steady state degrees of freedom; that means, when I am optimizing some objective function, which what is the objective function. Let us say let us say, I want to maximize operating revenue, what is operating revenue? Product rate times product price minus raw material rate times raw material price minus energy cost, that is the revenue that the plant generates right, I want to maximize this, usually what will happen? Is that the product price is what is making the money, energy is much cheaper than raw material of product price.

So, therefore, what happens is maximizing revenue actually corresponds to maximizing production. Particularly, if you can assume that, there is sufficient demand, you are the only guy, whose who can make that product. So, you there are no competitors, because you got the patent right. So, maximize production sufficient, market sufficient, this no matter, what you produce? It is not going to affect the price, you know fine. So, then maximizing production is, what you want to do?

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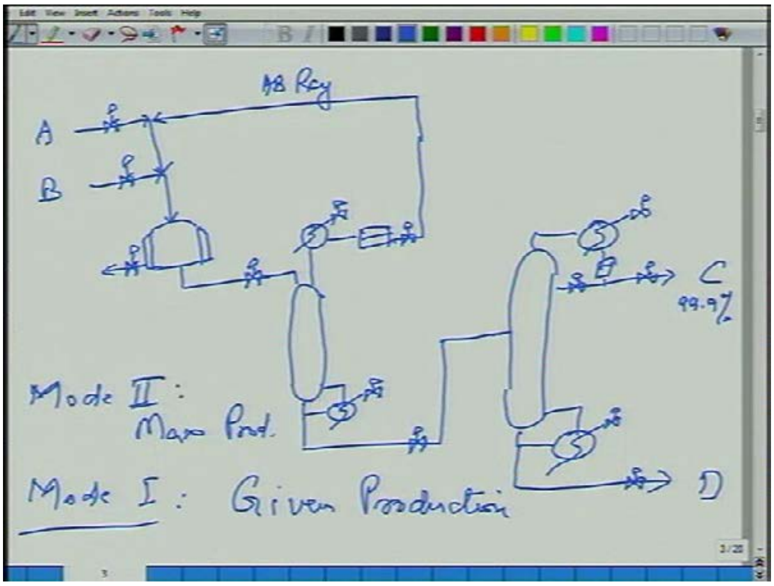

Another mode of operation, this is called you know, this is 1 mode, where you want to maximize production or maximize revenue or mode. Let us call this mode 2, there is another mode of operation, where what is the feed to be processed is given to you? Or how much product is to be made is given to you? Product rate is given make 100 kilomoles per hour of product C, which is 99.9 percent pure or 100 and 50 kilomoles per hour, because market demand is increasing, that will call mode 1.

So, mode 1 is essentially given, production mode 2 is, what max production, max achievable production, max production? Yes or no. Now, let us take mode 1; in mode 1, if I want to operate this process, economically from a steady state point of view; that means, I am I am I am I am considering my 7 degrees of freedom, how should they be adjusted. So, that my revenue is maximum for a given feed rate, for a given a feed rate for example.

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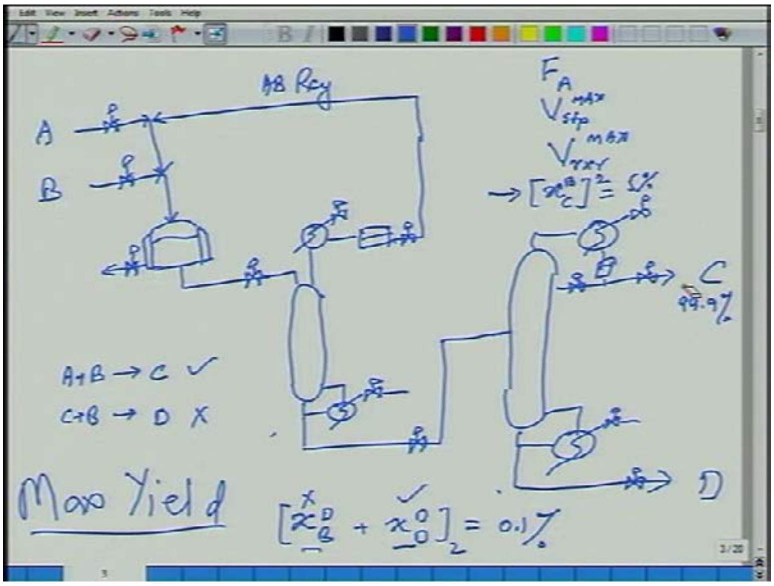

Reaction stochiometry is A plus B goes to C, C plus B goes to D, C is desirable, D is undesirable. So, how will I suppress the D production rate inside the reactor, I want to maximize C, minimize D right, because any D I make consumes, B also consumes C. So, any D; that gets made consumes 1 mole of A and 2 moles of B, yes or no? And I do not make any money on it, I am paying money for those many moles of A’s and B, A and B right. But I do not make any money on that D, so obviously, I need to do, what I need to minimize the D formation or the D production rate and maximize the C production rate.

Basically, I need to maximize the yield economic operation will typically correspond to for example, maximum yield yes or no, maximum yield to desirable product, how do I maximize the yield? can I take it? Will be such that D, you know activation energy of D is more than activation energy of C, which is, why C is the main reaction? D is the side reaction? Because the activation energy is more and both reactions; that are reversible, you change the temperature percentage, change in D formation will be more than percentage change in C formation, your yield will go down yes or no. We, I think we discussed that some time ago yeah.

So, once you understood that, tell me how the hell do I suppress the side reaction as a chemical engineer? You have to operate the reactor in excess, a yeah let me also tell you, energy is much cheaper than product or raw material?

So, how do I basically minimizing D corresponds to maximizing a inside the reactor; the excess of a inside the reactor, how do I achieve that. So, how do I maximize the recycle rate, you will have essentially operate the striper at flooding condition at maximum boil up. So, basically I have got 7 degrees of freedom, of those 7 fresh a rate is given to me. I am told at process 100 kilomoles per hour of a alternatively, C production rate may be given to me, basically 1 degree of freedom is gone it is set by throughput; that is gone. So, out of 7, 6 remain then maximizing yield requires boil up in the stripper should be maximum yeah.

What about reactor level; it should be maximum, because it minimizes the you see what will happen is, if I increase the level boil up will go down, because un reacted amount that is coming out is less high residence time, more conversion less un reacted material to be sent out, what that means, is I can increase the amount of boil up, back to maximum increase the recycle rate and then, I will get further separation of the side reaction. So, maximizing the level, minimizes the boil up or reduces the boil up, which allows me to increase it, increase the boil up. So, that recycle rate further increases. So, if I was able to operate at 50 percent level at a recycle rate of x at 100 percent level I will be or at 80 percent level, I will be able to operate at a recycle rate, which is x plus something that, extra recycle rate that I am getting will help me further suppress the side reaction yes or no, this is the qualitative argument.

So, I should also be operating the reactor at max level, yeah I want to produce 99.9 percent pure, what that means, is I have got only 0.1 percent impurity in the C stream, what are the impurities in the top stream D, that is it B and D any B that leaks out is Going to go up the top and D is Going to go up the top. Now, let us see that I give you something, which is you know that C is much lighter than D. So, the separation is easy separation is easy, if the it does not, it you know the energy consumption in the re boiler here in the second column, is essentially the energy it takes to send C up, the top B being heavy will go down, D being very heavy will go down. Naturally, there is no energy penalty for D going down, because D is the heavy by product.

So, how should I manage it, put your brains exactly you say, see D will anyway be a small strip, because you are running the reactor in excess in a large excess D will. So, for example, let us say C is 95 kilo moles an hour D may be 1 or 2 kilo moles an hour I want to make sure that whatever C I am producing it goes up the top, I do not lose it down the bottoms, what that means, is I would like to for example, but the separation is easy. So, it does not make sense to you, see what can happen is, because the separation is easy and I and I put the boil up here at max, then what will happen is D will start going up, the top and contaminating my product that should not happen right, then to reduce that contamination, what I will have to do is, I will have to increase the reflux.

So, then what I am having is unnecessary recirculation in the in the product column, I do not want that. I am that is essentially one way of screwing your own self. So, what I will do is I will say that look economic perspective, I want to minimize the loss of C down the bottoms, because C is what earns me money. So, let us say I am Going to control x C in the bottoms of the second column to be let us say, I do not know some value may be 1 percent or may be 5 percent, I would say 5 percent why am I saying 5 percent, because anyway D is very small ok that takes care of that, because the separation is easy. Well, let us see 1, 2, 3, 4 things have gone degrees of freedom is 7 right.

So, let us let us worry about the other degrees of freedom 99.9 percent is 1 spec 99.9 percent that takes care of. So, basically what I am saying is x B in the distillate plus x D component D in the distillate of column two; these are the two impurities right, this should be so, yeah. So, if we have fixed the re boiler duty to maximum, then whatever B is leaking down is, what is leaking down, see if re boiler duty is in your hands, you can dictate how much B should leak out? You can adjust the re boiler, no see re boiler duty here is max no I am not saying the re boiler duty in the second column is max, because the separation is easy well.

So, then that is being ensured by that 5 percent you can tighten it to 1 percent, you can even tighten it to 0.1 percent, basically this is taking care of that that too much C does not leaked on the bottoms that takes care of that yeah. So, one constrain is this we are saying that boil up in the first column should be max, once the boil up is maxed then what how much B is leaking out is not in my hands right. So, how much B is going up the distillate is not in my hands. So, this is not in my hands, this is in my hands my reflux must be adjusted. So, that what is not in my hands just this chap plus, what is in my hand sum of 2 1, yes or no this is in my hands, I can adjust how much D is leaking up, the top by adjusting, what no by adjusting the reflux by adjusting the reflux right and reflux is not constraint yes or no. If the last term is going to be very small; its magnitude will be comparable to energy consumption; its magnitude is Going to be comparable to energy consumption, I really cannot say that, they should be max or not.

We should go for some kind of optimization, if you say that, I do not what do an optimization, I will say just choose some reasonable value, where you are essentially ensuring too much C does not leak down the bottom, that is the basic idea.

Sure you can do an optimization, and come up what this value should be may be your optimizer, will say that look the kinetics is such that the D loss is too much and do you know, you know top stream is 70 down bottom stream is I do not know, top stream is 90 and bottom stream is 10, you know and then 5 percent loss is too much; and to reduce that you keep reducing it as you reduce it boil up gets max column gets flooded may be that that can happen too, but all I am saying is as very unlikely, when you are trying to maximize production, sure that will happen, this boil up will also hit max, but at the design whatever you have designed, the process for that throughput that is not Going to happen yeah.

You have designed the process for 100 kilomoles per hour throughput, there is sufficient over design in the column and then if the column is hitting max, then there is something fishy. So, basic idea is too much C should not leak out, and that we are ensuring by putting that constraint, last constraint here this one yeah. So, we have taken care of 1, 2, 3, 4, 5 things the 5th one is down there yeah, temperature is unconstrained reactor temperature is unconstrained, yes or no? Why the reactor temperature unconstrained? Because if the temperature is too high, selectivity goes for a task, if the reactor temperature is too low, conversion goes for a task.

So, somewhere in the middle you know temperature. So, temperature is unconstrained, what is the other thing, that is unconstrained yes, you see the way this process is you have to control some composition inside the recycle loop, otherwise either A or B is building up. So, what are the two unconstrained degrees of freedom, that we have left reactor temperature and that composition set point everything else is constrained steady state degrees of freedom for this process is 7, I am Going to adjust those 7 specification variables; those 7 degrees of freedom to get desired F A 1 to have V S T P at max 2 3 have reactor volume at max 4 have 5, only 5 percent loss of C in the bottoms byproduct stream 5th some of the impurities.

In the product stream to be 0.1 percent, then two things are left my question was, what are those two things? I am telling you those two things are reactor, temperature and some composition that, you are controlling to ensure that A or B does not buildup in the recycle loop does this make sense or no.

So, I have 7 steady state degrees of freedom, 5 of those steady state degrees of freedom have gotten taken away by economic considerations, what are those economic considerations F A told to be by management process. So, much because this is the market demand, maximum reactor level to minimize energy consumption or rather to maximize yield, because that allows me extra recycle extra recycle suppress the reaction further side reaction further maximum reactor conversion, same thing minimizing C lost down the bottoms make sense, it is an economic reason product purity.

So, of the 7 things that, I had 4 constraints are active production is given 5 things are gone, only 2 things remain in my hands, which are unconstraint the point is by arguing about constraints you see that these things need to be controlled tightly. So, for example, V S T P max must be controlled tightly yeah. So, now, let us start drawing a control system by the way this is at the design, tomorrow I may get a get a get an instruction, which says that look you need to jack up production tomorrow, I may get an instruction, because let us say a over broke out and over the next few days or over the next one month, this chemical is Going to be in great demand jack up production produce as much as you can.

So, today I am operating at design capacity 100 kilo moles per or these constrains are active 5 degrees of freedom are left, I can still play with those 2 left degrees of freedom, that are left with me to jack up my production yes or no yes or no, how would I do that. Now, let us say something happens the product of the price of C goes up too much. So, I would like to produce as much C product of C goes up too much. So, I do not to have to the price of C goes up too much, because there is some shortage some place etcetera. I want to produce as much as, I can, when I was processing 100 kilomoles in hour of a 2 degrees of freedom were left.

Now, I want to maximize production that; that means, I want to maximize f a itself. So, actually I have got 3 degrees of freedom, f a itself we do not know what the maximum production is plus whatever the two, that was left composition of a composition of no composition of a and reactor temperature, now if am operating this process and I am the operator and the two things, that are in my hands excluding f a are what reactor temperature and composition, how would I, how would I jack up how would I jack up production, well first thing, I would say is screw selectivity, I want to maximize not screw selectivity, some selectivity can go down a little bit, I can produce a little more D, but if I can jack up C, because C is earning me.

So, much. So, much more premium slight lose in selectivity is. So, what I will do is I will start jacking up the temperature of course, reactor temperature cannot be jacked up infinitely, as there the catalyst will start deactivating or you know vapor will start getting formed and that vapor will pressurize, the reactor and then, you will reach a pressure limit, which cannot be exceeded and then you. So, cannot jack up the temperature beyond this right, there is some constraint on the temperature. So, I will start increasing the temperature hits max that degree of freedom is gone, then what I do not think you I do not think at well yes or no I think the answer is no this column.

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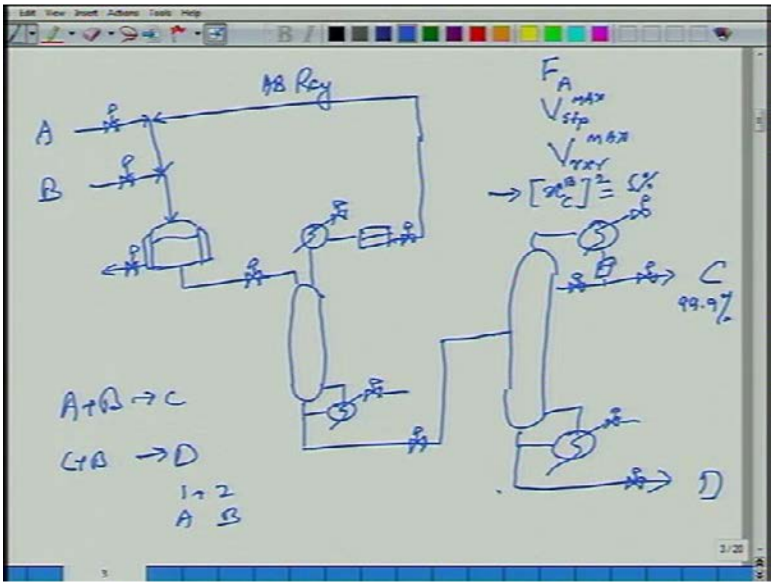

You see what is this column doing? This column essentially doing a C CD separations. Economic sustains such that you can allow a little bit of D to go down, but not too much C you know whatever, D is going down that is not earning you money; you may be you can allow a little more C to go down so, leave this column out; let us let us play with the reactor. Two degrees of freedom was there with the reactor right, what was those two degrees of freedom?

Student: (( ))

Temperature and level was max composition. What can I do to the composition? Earlier I was keeping the B composition small. So, that side reaction is suppressed. Now I am saying I can take a hit in the selectivity because any C I produce makes be tones of money. Even if I produce a little bit more D it does not matter. So, what do I do? I start jacking up the C composition set point 2. First of first of all I maximize the reactor, now I start increasing the amount of B composition inside the reactor, limiting reactant composition let us say earlier it was 5 percent, now I am jacking it up may be to 10 percent. More D gets produced agreed; however, the difference in the C and the raw material price have increased, so much that that the extra D production actually is more than compensated for by the extra C production. Yes or no? This did not make sense it is it is 950 may be we have to end in the in the worst cast, let us say raw material is free, then what?

Student: (( ))

Purity is being ensured, purity is being ensured by the reflux. So, raw material is freed pay there is no penalty you know this is also not earning me anything, then basically my objective function is maximize C do not worry about how much raw material you are sucking in no composition no I do not care about selectivity any more no of course, you are producing more no 100 see I think, it is it is overall material balance I think you are getting.

It not right no selectivity means at 100 let us say selectivity was 95 percent I am putting in 100 moles of a and I am getting out 95 moles of C, and may be 2.5 moles of D I go to 150 in the same ratio what should C be simpler 190, and this should be 5 what I had tell you is selectivity has taken ahead it is not 190, now it is 180 and D has gone up to whatever the hell just a second.

So, now, this 190 or 180 is making me money lot of money D I am not being charge the penalty A and B are cheap. So, cheap that I let us say I call it 0 does it. So, so the hit in selectivity make sense or no it makes make sense, that is what I am saying whether you can take a hit in selectivity or not is basically determinant by C minus A and B price, in that price differential has gone up sufficiently because there was a war because, whatever the hell there is some legislation that came that basically said that product cannot be used, now this is only the alternative others will catch up, but it will take one year to catch you are the only producer of that product in the market [FL] as long as it is small do you see what I am saying yes or no.

So, now, the instruction from above that has come to me is jack up production maximize [FL] that is what has come to me, how would I do that no that is not true sure, but as far as if that, whatever D gets consumed that much extra B I have to put just a second a plus B goes to C, C plus B goes to D, this is what we have right whatever ,D gets produced because C is getting consumed to produce D, whatever D I am producing that requires 1 2 moles of B because C is already consuming 1 mole of B, and 1 mole of A.

So, any mole of D is actually 1 plus 1 mole of A and 2 moles of B, yes or no that much extra a and B I will have to put in all I am saying is that since, D is reasonably small compared to C 95 percent or 92 percent, but never the less largely the production is 90 percent or more towards C, that does not hit me economically the economical benefit of producing more C at the expense of producing slightly, more D out ways whatever it is that you are saying do you see what I am saying.

So, therefore, I will say selectivity loss can be taken from 95 percent the selectivity has gone down may be to 92 percent or from 98 percent it has gone down to 95 percent, economic scenario is such that I want to produce as much C because, that that is making a lots of bucks for me, does this make sense or no that is what I has to be done time has run out, so shit.